HEALTH SCIENCES FACILITY III
Baltimore, Maryland

KATHRYN GONZALES

Penn State Architectural Engineering

Construction Management

Advisor| Dr. Somayeh Asadi

Spring 2015

HEALTH SCIENCES FACILITY III

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Project Team

UNIVERSITY of MARYLAND

h+k

Barton Malow

CAGLEY & ASSOCIATES

MILLER, LONG & ARNOLD

AEI Affiliated Engineers

M.C. DEAN BUILDING INTELLIGENCE

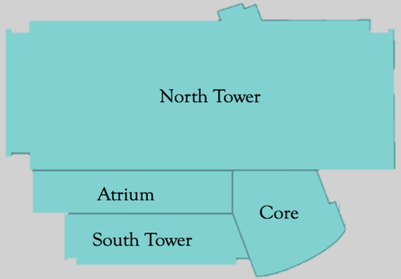
WFT ENGINEERING, INC.

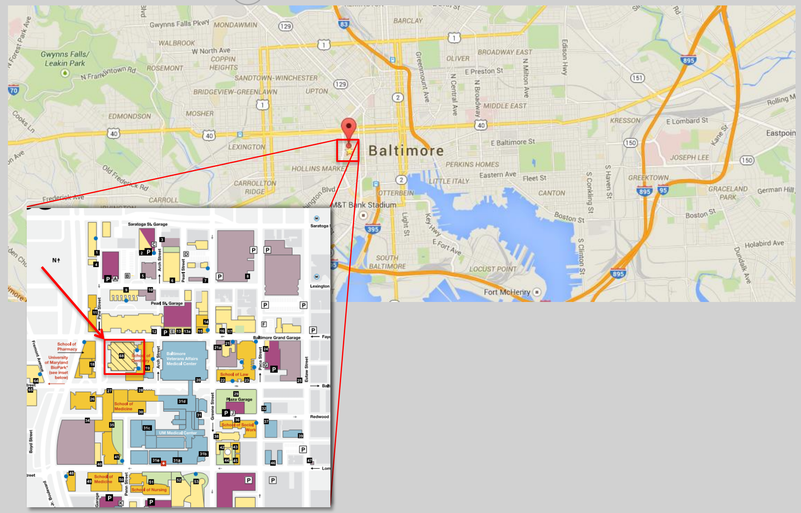
Southland

TSI CORPORATIONS

Project Information

Building Name	**Health Sciences Facility III**
Building Location	**Baltimore, MD**
Size	**435,000 GSF**
Number of Stories	**11 above grade, 2 below**
Construction Date	**July 2013-September 2017**
Construction Cost	**$206 Million**
Delivery Method	**CM at Risk**





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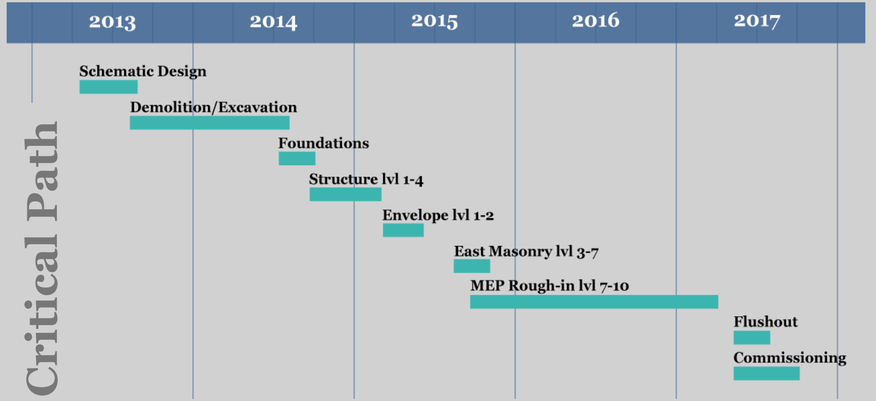
Project Information

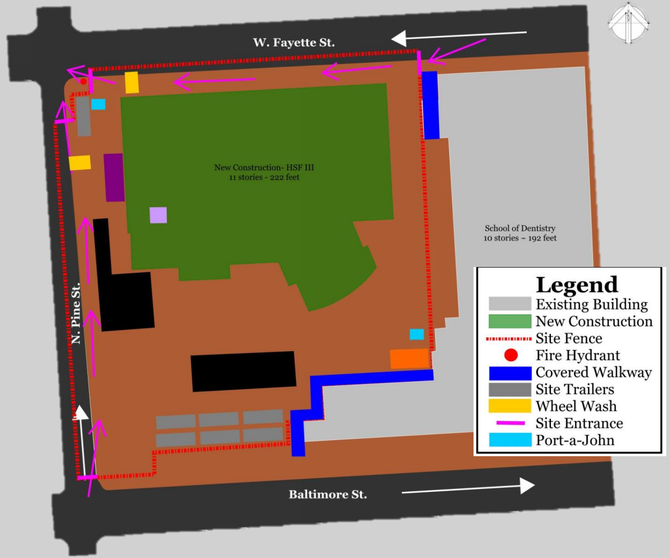
Construction Cost

System	Amount
Demolition/Excavation	$7,616,000
Structure	$21,297,000
Envelope	$34,726,000
Mechanical/Plumbing	$62,903,000
Electrical	$32,357,000
Fire Protection	$1,965,000
Sitework	$2,672,800
Other	$42,956,200
General Conditions	$10,130,300
Total	**$ 206,493,000**

|Critical Path



|Site Logistics



Analysis 1 | Shoring System

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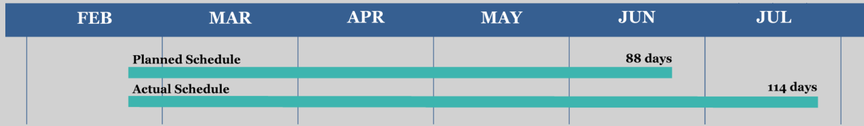
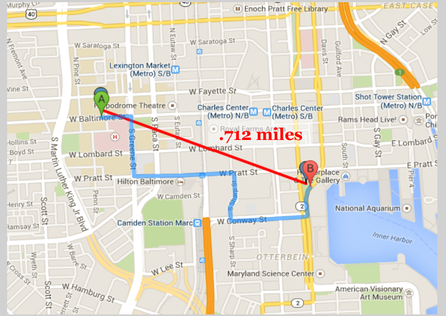
|Pile and Lagging

Advantages	Disadvantages
• Versatile to adjustments in the field	• Difficult to use with high water tables
• Fast to Construct	• Poor backfilling can lead to settlement
• Cheaper installation compared to other systems	• Not as stiff as other shoring methods
• Does not require advanced construction techniques	





Shoring	$1,480,000
Dewatering Issues	$650,000
New Total	$2,130,000

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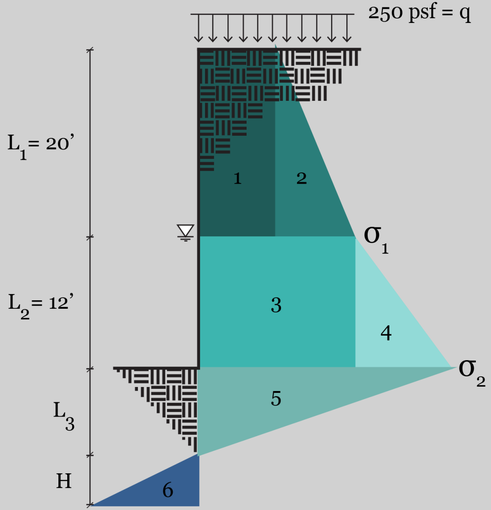
Structural Breadth



Assumed Values

Soil Property	Amt	Unit
Water Table	20	ft
Angle of Friction, ϕ	35	Degrees (°)
Moist Unit Weight, γ	125	pcf
Sat Unit Weight, γ_{SAT}	145	pcf
Construction surcharge, q	250	psf
Allowable bearing, q_a	5000	psi
Soil Type	SM	--

Calculated Values

Property	Amt	Unit
$\gamma'=\gamma_{SAT}-\gamma_w$	82.6	pcf
k_a	.271	
k_p	3.69	

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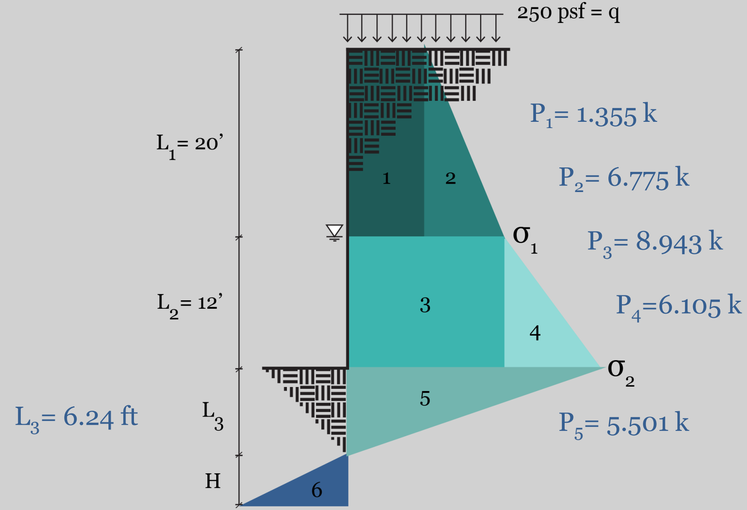
Structural Breadth



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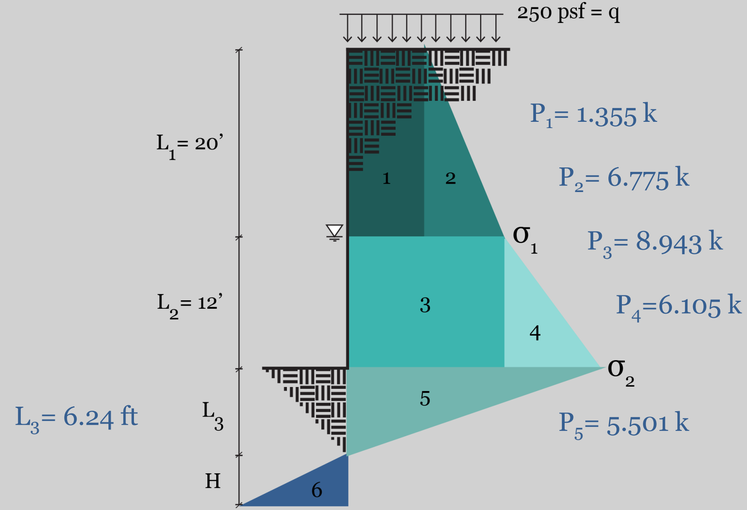
Structural Breadth



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Without Tiebacks

H= 24.4 ft
Total height= 62.64 ft

With Tiebacks

H= 5.5 ft
Total height= 44 ft
Tieback Force= 24k/ft

Shear and Moment

Mu=239ft ·k
Vu= 23.3 k

Structural Breadth

|Sheet Piles

Solution Estimate

SKZ 38
Skyline Steel

Z-Sheet Pile	
name	SKZ 38
units	400
height	44.00 ft
weight per ft	88.95 lb/ft
total weight	782.747 short tons

Summary

wall height	44.00 ft
target wall length	948.00 ft
actual wall length	950.00 ft
panel quantity	400
pieces to install	400
WADIT® sealant	17,600.00 ft
choose WADIT® sealant	
wall area	41,800.00 ft^2
panel weight	88.95 lb/ft
weight per ft^2	37.45 lb/ft^2
section modulus	62.32 in^3/ft
moment of inertia	560.85 in^4/ft
total weight	782.747 short tons

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Structural Breadth

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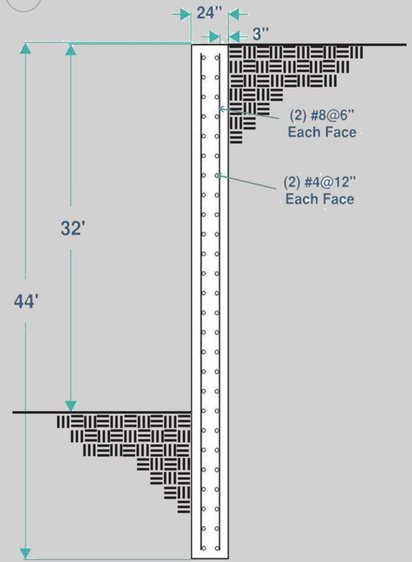
|Slurry Wall

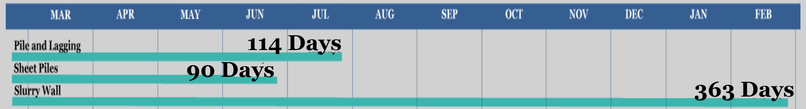


Comparison Matrix

|Cost

Shoring System	Price
Pile and Lagging	$2,130,000
Sheet Piles	$1,640,000
Slurry Wall	$3,029,810

|Schedule



|Recommendations

Sheet Piles Recommended ✓

	Pile and Lagging	Sheet Piles	Slurry Wall
Availability	✔	✔	✔
Constructability		✔	
Cost	✔	✔	
Schedule	✔	✔	

Analysis 2 | Motivation

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Question: What are the drivers of motivation and how does that correlate with team performance?

Audience: Construction Managers

Method: Literature review and industry survey

Survey Results

Drivers of Motivation

- A respectable leader
- Formal recognition
- Promotional opportunities
- Time off
- A challenging project
- Money
- A complex project
- Negative consequences
- Team reputation
- Negative feedback
- An unmotivated team leader
- The team
- When believe in the cause

Not at All	Very Little	Somewhat	Significantly	Very Significantly

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Survey Results

Drivers of Motivation

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Not at All	Very Little	Somewhat	Significantly	Very Significantly

Driver	% Significant	Driver	% Insignificant
Believe in Cause	100	Unmotivated Team Member	60
Respectable Leader	97	Negative Consequences	43
A Challenging Project	83	Negative Feedback	27
Team reputation	80	Time Off	20
Assuming Leadership Position	77	Formal Recognition	7
A Complex Project	73	Promotional Opportunities	7
The Team	63	Team Reputation	7
Promotional Opportunities	60	Money	3
Money	57	A Complex Project	3
Time Off	53	The Team	3
Formal Recognition	50	Respectable Leader	0
Negative Consequences	37	A Challenging Project	0
Negative Feedback	27	Assuming Leadership Position	0
Unmotivated Team Member	10	Believe in Cause	0

Survey Results

Positive Correlation

Driver #1	Driver #2	Degree of Correlation
A complex project	A challenging project	.70
When believe in the cause	The team	.58
The team	Motivated leader influences team performance	.54
Formal recognition	Promotional opportunities	.51
Promotional opportunities	Time off	.45

Negative Correlation

Driver #1	Driver #2	Degree of Correlation
Money	Degree motivation related to team performance	-.44
A complex project	Motivated leader influences team performance	-.43
Money	Assuming a leadership position	-.40
A complex project	Unmotivated leader influences team performance	-.39
Money	Motivated leaders influences team performance	-.38

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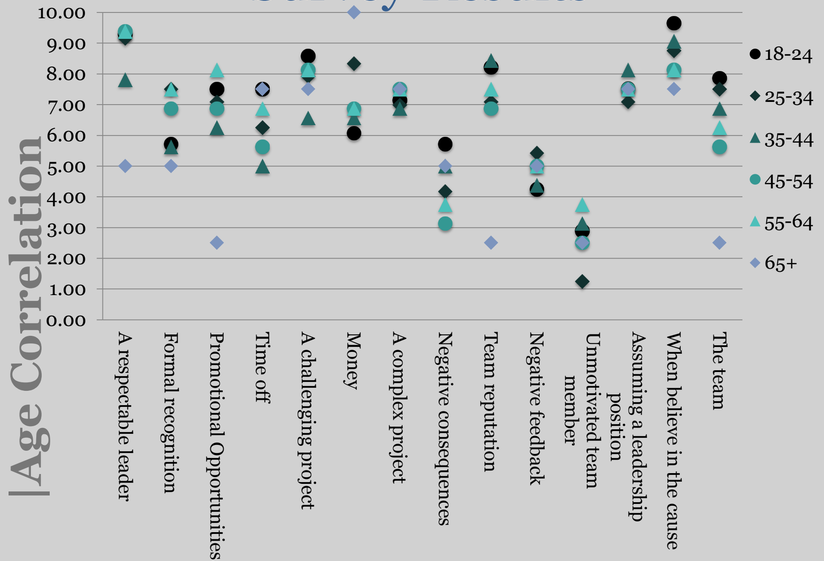
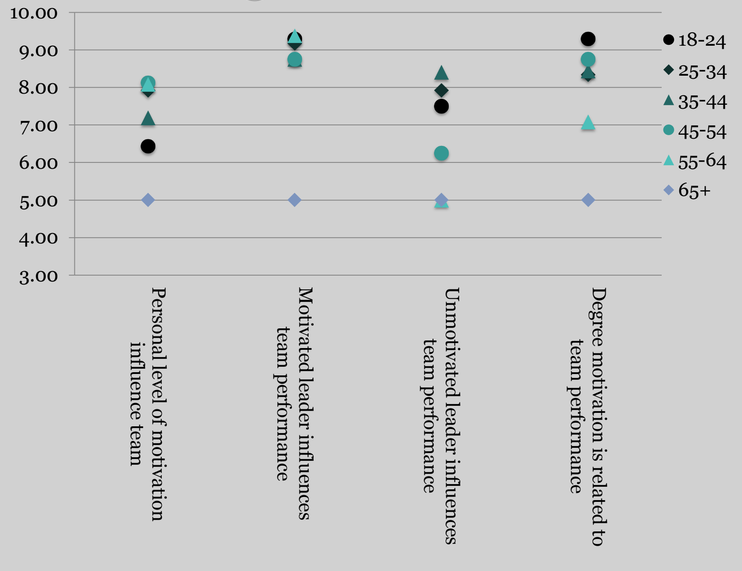
Survey Results





|Open-Ended Questions

Survey Results

What do you think is the most effective way to motivate your team?

- Communication
- Family community
- Good leadership
- Positive recognition
- A good attitude
- Be an example
- Clear goals
- Understand the individuals on the team

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|Open-Ended Questions

Survey Results

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How does conflict affect motivation or team performance?

> If handled well, conflict can become a rallying point for a team. Conflict has a tendency to motivate me to push harder and stake my position on the high road.

> Humans will not want to do something that they do not feel comfortable doing or if conflict exists between people. Team performance will be affected if conflict exists because the team will not trust each other and it will hinder communication between the two parties.

Analysis 2 | Motivation

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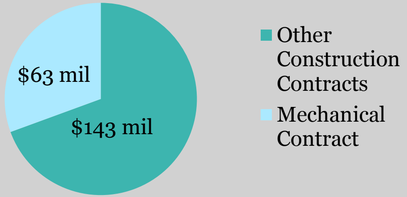
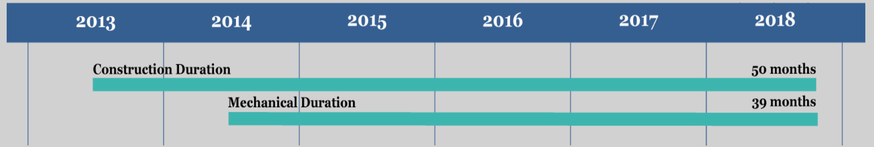
|Results

1. **Two major drivers of motivation:**
   - **Belief in the cause**
   - **Respectable leader**
2. **Negative motivators**
3. **Age correlation**
4. **Trust and communication**
5. **Conflict and team performance**

Analysis 3 | Cash Flow

Fiscal Year	Funding (million)
FY 2014	$18
FY 2015	$59
FY 2016	$91.5
FY 2017	$53
FY 2018	$9.5
Total	$231





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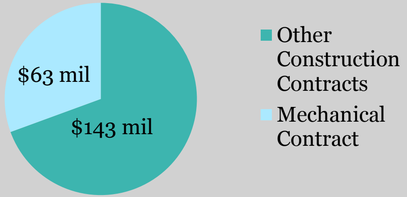

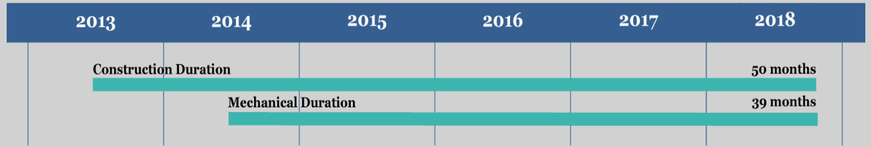

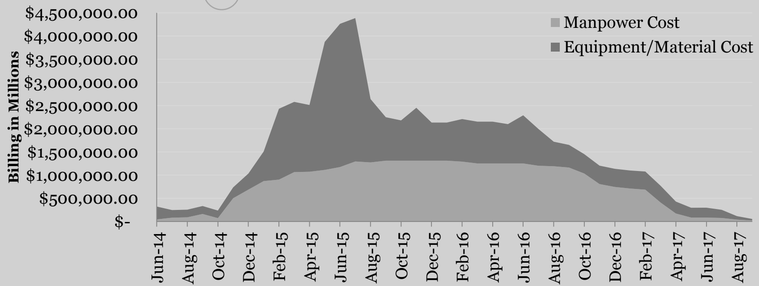

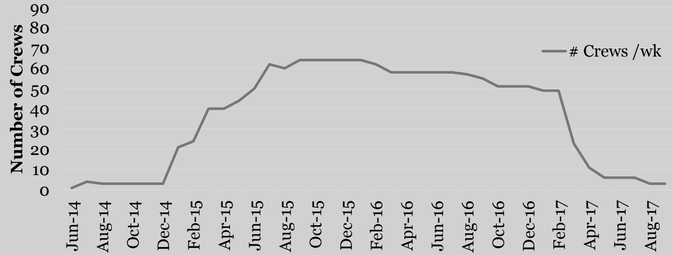

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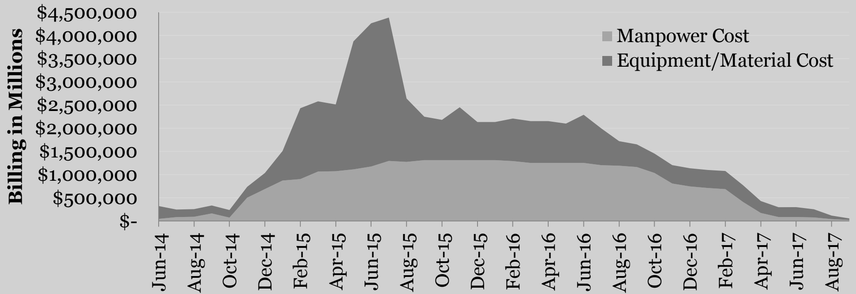
Mechanical Review of Cash Flow



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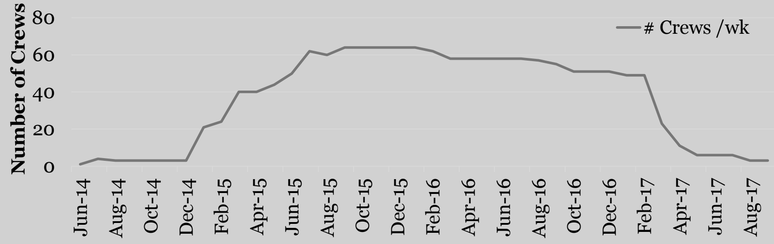
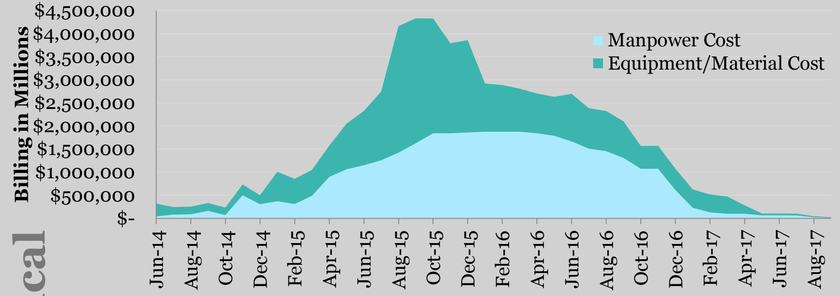
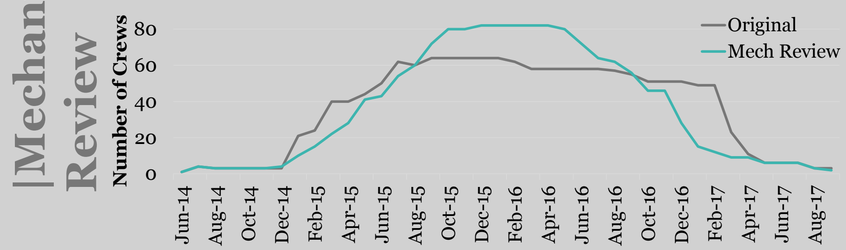




|Mechanical Review



HEALTH SCIENCES FACILITY III

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Legend

- Mechanical Basement
- Mechanical Shaft/Risers
- Mech LP/UP
- Sleeves/ Inserts
- Overhead/ In wall
- Connect Service Panel
- Connect Lab Equip
- TAB
- Commissioning

Mechanical Review Man-loaded Schedule

iew Man-edule	Jun-14	Jul-14	Aug-14	Sep-14	Oct-14	Nov-14	Dec-14	Jan-15	Feb-15	Mar-15	Apr-15	May-15	Jun-15	Jul-15	Aug-15	Sep-15	Oct-15	Nov-15	Dec-15	Jan-16	Feb-16	Mar-16	Apr-16	May-16	Jun-16	Jul-16	Aug-16	Sep-16	Oct-16	Nov-16	Dec-16	Jan-17	Feb-17	Mar-17	Apr-17	May-17	Jun-17	Jul-17	Aug-17	Sep-17
Mechanical Basement								6	8	15	15	15	17	18	18	12	12	12	12	12																			
Mechanical Shafts/Risers									3	3	3	12	12	12	12	12	12	12	10	5	5																		
Mechanical Penthouse/Roof																18	22	22	18	18	18	15	15	12															
Basement	1	2	1																		8	8			2	2													
Level 1		2	2	3							6	10	10	10	10	10	10	10	2		5		8			4	2												
Level 2					3	3								10	10	10	10	10	2	2	5			8			2	2											
Level 3							4									10	10	10	15	10	10	4	5		10			2	2										
Level 4								4										3	15	15	10	10	2	2	5		10			2	2								
Level 5									4														10	5	5			5			1								
Level 6										2														5	10	5		5			1								
Level 7										2										10	10	10	10	10	10	4	5		10			2							
Level 8											4									10	10	10	10	10	10	10	4	5		10		2	2						
Level 9												2										10	10	10	10	10	10	4	5		10		2						
Level 10												2										10	10	10	10	10	10	10	5		10		4						
Penthouse													4										4	4	1	1												
Roof														4	4								4	4	1	1												
Miscellaneous															6		4	1			4		2		11	19	23	27	27	14	1	8	5	5	6	6	6	3	2
Total Manpower	1	4	3	3	3	3	4	10	15	22	28	41	43	54	60	72	80	80	82	82	82	82	82	80	72	64	62	56	46	46	28	15	12	9	9	6	6	6	3	2

Modified Man-loaded Schedule

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Legend

- Mechanical Basement
- Mechanical Shaft/Risers
- Mech LP/UP
- Sleeves/ Inserts
- Overhead/ In wall
- Connect Service Panel
- Connect Lab Equip
- TAB
- Commissioning

led Schedule

	Jun-14	Jul-14	Aug-14	Sep-14	Oct-14	Nov-14	Dec-14	Jan-15	Feb-15	Mar-15	Apr-15	May-15	Jun-15	Jul-15	Aug-15	Sep-15	Oct-15	Nov-15	Dec-15	Jan-16	Feb-16	Mar-16	Apr-16	May-16	Jun-16	Jul-16	Aug-16	Sep-16	Oct-16	Nov-16	Dec-16	Jan-17	Feb-17	Mar-17	Apr-17	May-17	Jun-17	Jul-17	Aug-17	Sep-17
Mechanical Basement								6	8	15	15	15	18	18	18	12	12	12	12	10	3																		
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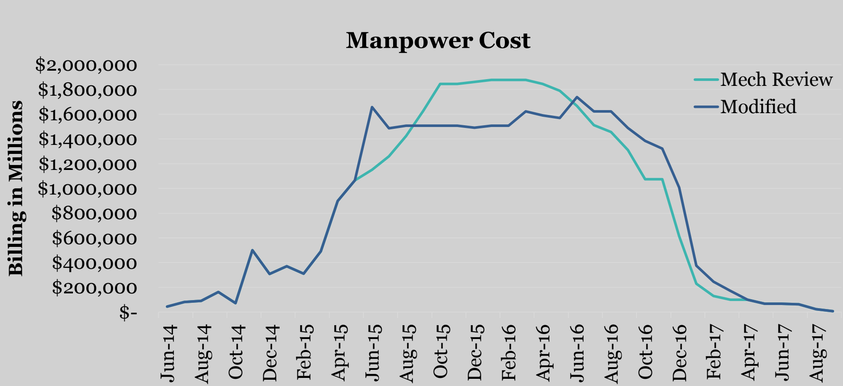
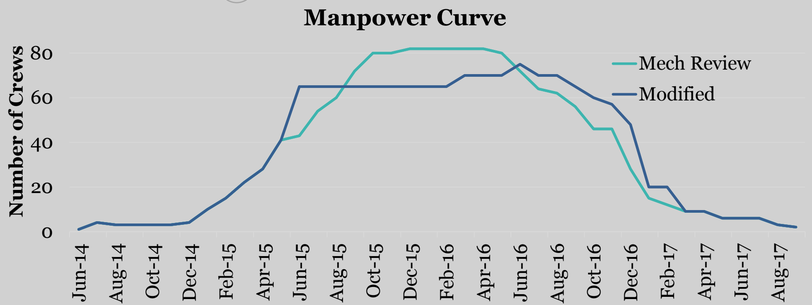
Basement	1	2	1																			6	5	5	2	2													
Level 1		2	2	3							6	10	15	15	10	10	10		2		5				8		4	2											
Level 2					3	3							15	15	15	10	10	5		2	2	5				8		2	2										
Level 3							4									10	10	10	10	10	10	4	5				10		2	2									
Level 4								4										3	15	10	10	10	5	4	5			10		2	2								
Level 5									4																	10	5	5		5	2								
Level 6										2																	5	5	10	5	2								
Level 7										2										5	5	10	10	10	10	10	4	5		10		2							
Level 8											4									5	5	10	10	10	10	10	10	4	5		10	2	2						
Level 9												2										5	10	10	9	10	10	5	4	5		10	2						
Level 10												2										5	10	10	8	8	10	10	10		5		10	4					
Penthouse													4											4	4	1	1							4					
Roof														4	4									4	4	1	1												
Miscellaneous															6			1			4					6	10	17	27	28	27	6	6	5	5	6	6	6	3	2
Total Manpower	1	4	3	3	3	3	4	10	15	22	28	41	65	65	65	65	65	65	65	65	65	70	70	70	75	70	70	65	60	57	48	20	20	9	9	6	6	6	3	2

HEALTH SCIENCES FACILITY III

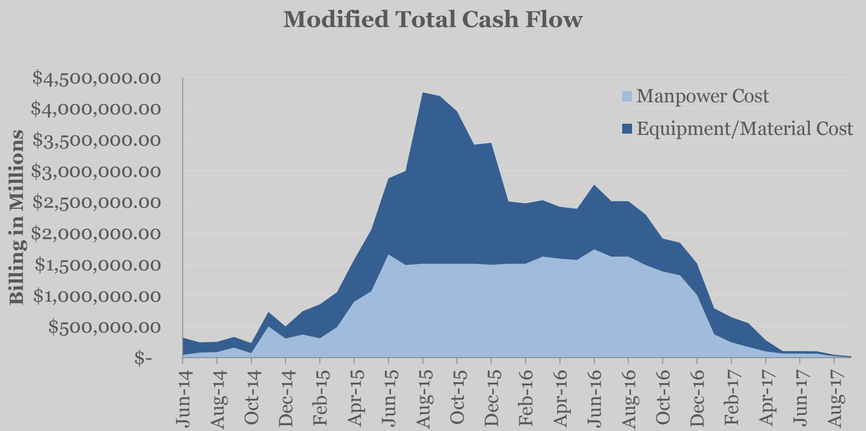
Modified Man-loaded Schedule





Fiscal Year	Funding	Mechanical Review Billing	Modified Billing	Difference
FY 2014	$18,000,000	$321,700	$321,700	--
FY 2015	$59,000,000	$10,910,600	$11,463,500	$552,900
FY 2016	$91,500,000	$39,874,100	$37,377,100	($2,497,000)
FY 2017	$53,000,000	$13,141,800	$15,086,200	$1,944,500
FY 2018	$9,500,000	$173,900	$174,000	$100

Analysis 3 | Cash Flow



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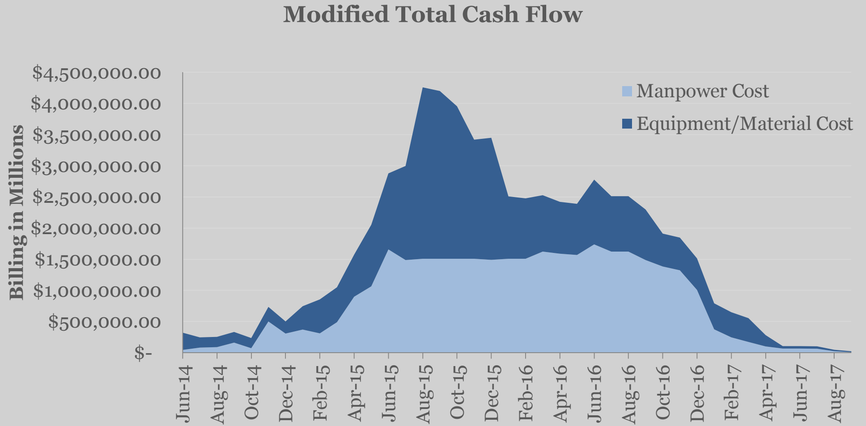
Analysis 3 | Cash Flow



|Recommendations

Resource Leveling Recommended ✓

Final Remarks

Analysis 1
Shoring System

Sheet Piles
Recommended ✓

Final Remarks

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Analysis 1
Shoring System

Sheet Piles Recommended ✓

Analysis 2
Motivation

1. **Two major drivers of motivation:**
   - **Belief in the cause**
   - **Respectable leader**
2. **Negative motivators**
3. **Age correlation**
4. **Trust and communication**
5. **Conflict and team performance**

Final Remarks

Analysis 1 Shoring System

Sheet Piles Recommended ✓

Analysis 2 Motivation

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2. **Negative motivators**
3. **Age correlation**
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Analysis 3 Cash Flow

Resource Leveling Recommended ✓

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Final Remarks

Analysis 1 Shoring System

Sheet Piles Recommended ✓

Analysis 2 Motivation

1. **Two major drivers of motivation:**
   - **Belief in the cause**
   - **Respectable leader**
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3. **Age correlation**
4. **Trust and communication**
5. **Conflict and team performance**

Analysis 3 Cash Flow

Resource Leveling Recommended ✓

|Acknowledgements

Academic

Dr. Somayeh Asadi
Dr. Rob Leicht
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Bill Gamble
Chris Brooks

Other Industry Leaders
Jason McFadden

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Baltimore, Maryland

KATHRYN GONZALES

Penn State Architectural Engineering

Construction Management

Advisor| Dr. Somayeh Asadi

Spring 2015

Questions?

Appendix

Active Forces

$P_1 = k_a q L_1$
$= .271(250)(20) = \mathbf{1355\ lbs}$

$P_2 = \frac{1}{2}k_a \gamma L_1^2$
$= .5(.271)(125)(20)^2 = \mathbf{6775\ lbs}$

$P_3 = k_a(q + \gamma L_1)L_2$
$= .271(250 + 125(20))12 = \mathbf{8943\ lbs}$

$P_4 = \frac{1}{2}k_a(\gamma_{SAT} - \gamma_W)L_2^2 + \frac{1}{2}\gamma_W L_2^2$
$= .5(.271)(145 - 62.4)(12)^2 + .5(62.4)(12)^2 = \mathbf{6105\ lbs}$

$L_3 = \frac{\sigma_2}{\gamma'(k_p - k_a)}$
$= \frac{1763}{82.6(3.69 - .271)} = \mathbf{6.24\ ft}$

$P_5 = \frac{1}{2}\sigma_2 L_3$
$= .5(1763)(6.24) = \mathbf{5501\ lbs}$

Passive Forces

$P_6 = \frac{1}{2}k_p \gamma' H^2$
$= .5(3.69)(82.6)H^2 = \mathbf{152H^2}$

Sum of Moments (without tieback)

$\sum M_O = P_1\left(H + L_3 + L_2 + \frac{L_1}{2}\right) + P_2\left(H + L_3 + L_2 + \frac{L_1}{3}\right) + P_3\left(H + L_3 + \frac{L_2}{2}\right) + P_4\left(H + L_3 + \frac{L_2}{3}\right) + P_5\left(H + \frac{2L_3}{3}\right)$
$= 1355\left(H + 6.24 + 12 + \frac{20}{2}\right) + 6775\left(H + 6.24 + 12 + \frac{20}{3}\right) + 8943\left(H + 6.24 + \frac{12}{2}\right) + 6105\left(H + 6.24 + \frac{12}{3}\right) + 5501\left(H + \frac{2(6.24)}{3}\right)$
$= \mathbf{401869 + 28659H}$

$\sum M_R = P_6\frac{H}{3}$
$= 152H^2\frac{H}{3} = \mathbf{50.7H^3}$

$F.S. = 1.5 \quad \longrightarrow \frac{M_O}{M_R} = 1.5 \quad \longrightarrow M_O = 1.5M_R$

$M_O = 1.5M_R$
$401869 + 28659H = 1.5(50.7)H^3$
$-76H^3 + 28659H + 401869 = 0$
$\boldsymbol{H = 24.4\ ft}$

Total height = L1 + L2 + L3 + H
=20+12+6.24+24.4=**62.64ft**

Sum of Moments (with tieback)

$\sum F_X = P_1 + P_2 + P_3 + P_4 + P_5 - P_T - P_6$
$= 1355 + 6775 + 8943 + 6105 + 5501 - P_T - 152H^2$
$= 28659 - P_T - 152H^2$
$P_T = 28659 - 152H^2$

$M_T = P_T(H + L_3 + L_2 + L_1 - 10')$
$= P_T(H + 6.24 + 12 + 20 - 10)$
$= P_T(H + 28.24)$

$M_O = M_R - M_T$
$401869 + 28659H = 76H^3 - P_T H + P_T 28.24$
$401869 + 28659H = 76H^3 - (28659 - 152H^2)H + (28659 - 152H^2)28.24$
$\boldsymbol{H = 5.5\ ft}$

Total height = L1 + L2 + L3 + H
=20+12+6.24+5.5=43.74ft~**44ft**

$P_T = 28659 - 152(5.5)^2 = 24061\ lbs = \mathbf{24k/ft}$

Appendix

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$M_a = 145.6ft \cdot k$
$M_u = 1.64M_a$
$M_u = 1.64(145.6) = \mathbf{239ft \cdot k}$

$V_a = 14.2k$
$V_u = 1.64V_a$
$V_u = 1.64(14.2) = \mathbf{23.3k}$

Calculate Shear on Wall

$\phi V_n = \phi 2\sqrt{f'c}bd$
$\phi V_n = .9 * 2\sqrt{5000}(12)(20)$
$\phi V_n = \mathbf{30.5k} > 23.3k \quad ok\checkmark$

Calculate Moment on Wall

$a = \frac{A_s * f_y}{.85f'c\ b}$
$a = \frac{A_s * 60}{.85(5)(12)} = 1.18A_s$

$\phi M_n = \phi A_s f_y (d - \frac{a}{2})$
$239 = .9(A_s)(60)(20 - \frac{1.18A_s}{2})$
$A_s = 2.90\ in^2$

Use (2 layers) #8 @6" -> $A_s = 3.14\ in^2$

New d = 24"-3"-1"-.5"=19.5"

Check Shear and Moment

$\phi V_n = \mathbf{29.8k} > 23.3k \quad ok\checkmark$
$\phi M_n = .9(3.14)(60)(19.5 - \frac{1.18 * (3.14)}{2})$
$\phi M_n = 2992\ in \cdot k = \mathbf{249ft \cdot k} > \mathbf{239ft \cdot k} \quad ok\checkmark$

Check Steel

$\beta = .85 - .05(f'c - 4) = .85 - .05(5 - 4) = .80$
$c = \frac{a}{\beta} = \frac{3.71}{.8} = 4.63$
$\varepsilon = \frac{.003}{c}(d - c)$
$\varepsilon = \frac{.003}{4.63}(19.5 - 4.63) = \mathbf{.0096} > \mathbf{.005} \rightarrow\ \boldsymbol{\phi = 0.9}$

Horizontal Reinforcement

$\rho = \frac{A_s}{bd}$
$A_s = \rho bd = .002(12)(12) = .288$
A_s = (2 layers) #4@12"=.40in²
A_s = .40>.288 ok✓

Vertical Reinforcement

As seen above:
A_s = (2 layers) #8@6"= 3.14 in²
$\rho = \frac{A_s}{bd}$
$\rho = \frac{3.14}{(12)(19.5)}$
$= .013 > .0033$ ok✓

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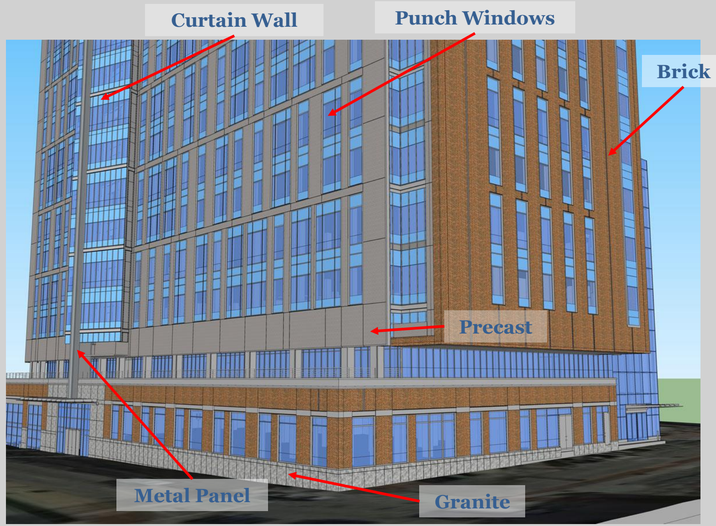
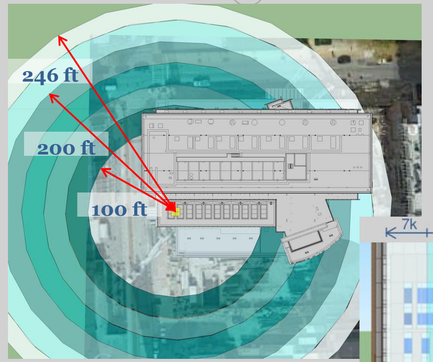
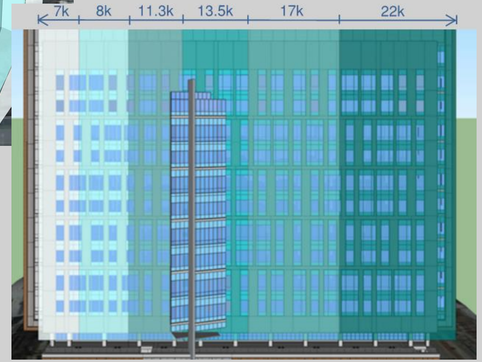
Architectural Breadth







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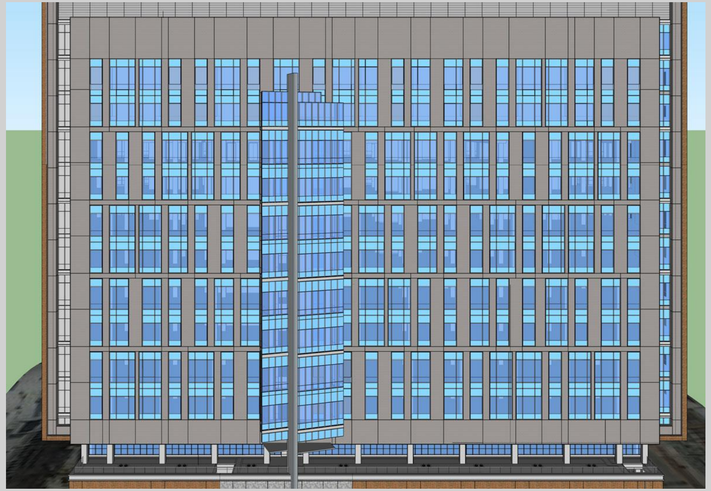
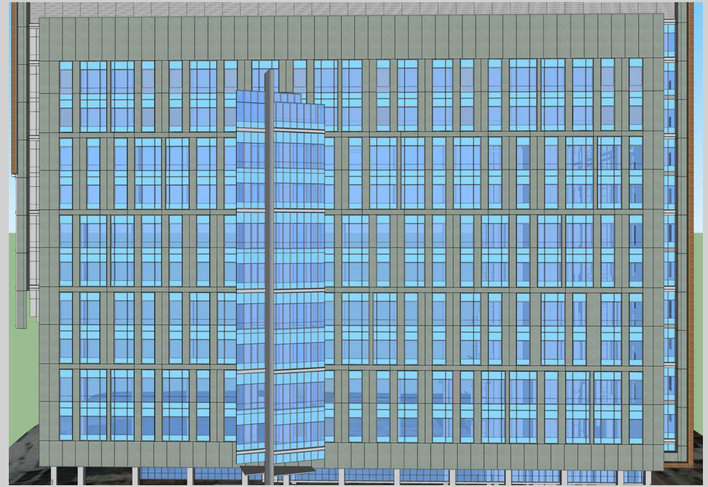
Architectural Breadth

|Original



|Modified



Architectural Breadth

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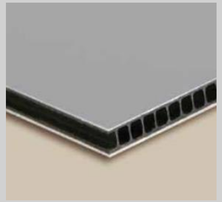
|Material Selection

Omega-Lite®



Material Restrictions
- 60” width
- Limited to certain colors

R-Value
- Precast: 1.22
- Metal Panel: 2.63

Cost/SF
- $103
- $44

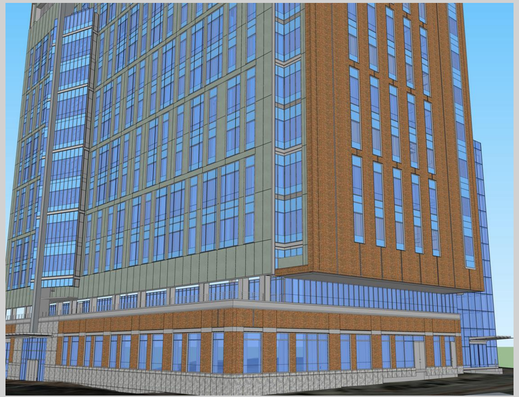
|Recommendations

Better R-Value

Cheaper Cost/SF

Similar Panel Layout

Metal Panel
Recommended ✓



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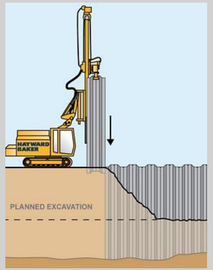
Alternative Systems

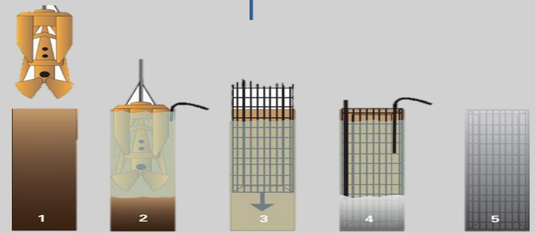
|Sheet Piles

Advantages	Disadvantages
• High resistance to driving stress	• Difficult to use in permanent application
• Quick installation	• Soil type greatly affects the cost and schedule
• Long service life when properly protected	• Installation method could disturb neighboring buildings
• Can be reused on multiple projects	



|Slurry Wall

Advantages	Disadvantages
• Good for applications with high water table	• More expensive
• High stiffness	• Requires more working space than other systems
• Does not need backfill	• Longer installation time



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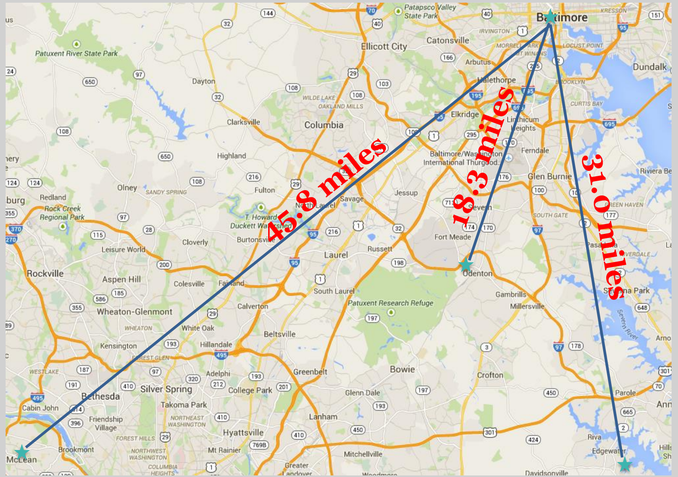
Comparison Matrix

|Availability

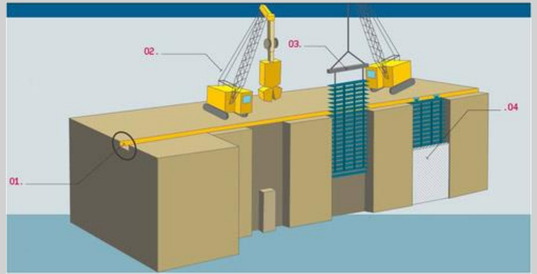


|Constructability

Pile and Lagging

Sheet Piles

Slurry Wall



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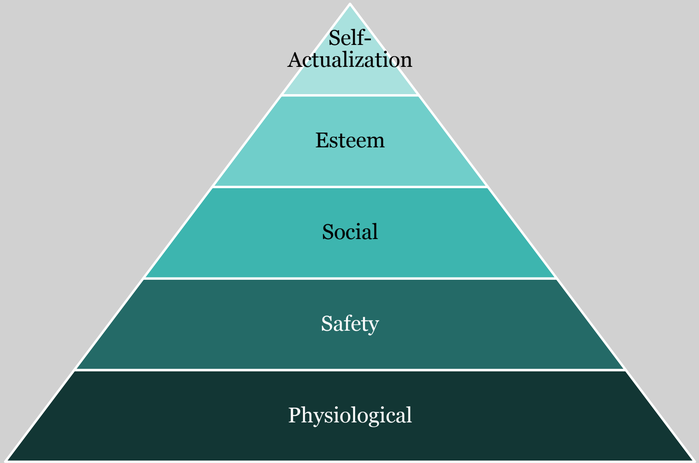
Literature Review

|Maslow's Hierarchy of Needs



|5 Dysfunction of a Team

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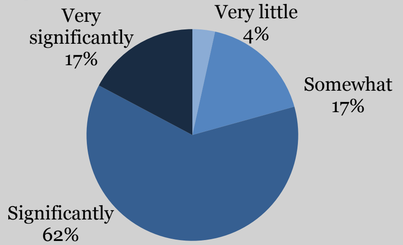
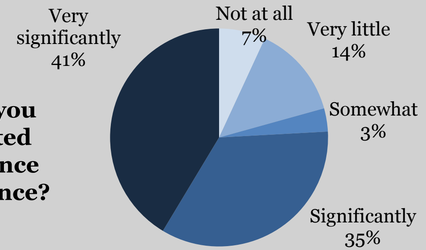
Team Performance

Survey Results

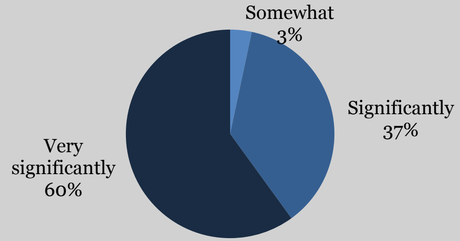
To what degree do you think your level of motivation influences your team?



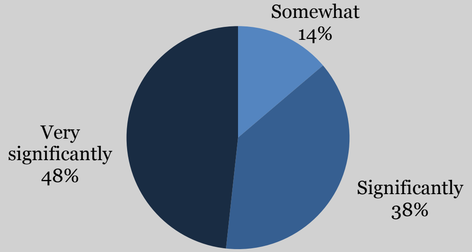
To what degree do you think an unmotivated leader would influence your team performance?



To what degree do you think a motivated leader influences your team performance?



To what degree do you think motivation is directly related to team performance?



HEALTH SCIENCES FACILITY III

Legend

- Mechanical Basement
- Mechanical Shaft/Risers
- Mech LP/UP
- Sleeves/ Inserts
- Overhead/ In wall
- Connect Service Panel
- Connect Lab Equip
- TAB
- Commissioning

Original Man-loaded Schedule

1-Loaded ule	Jun-14	Jul-14	Aug-14	Sep-14	Oct-14	Nov-14	Dec-14	Jan-15	Feb-15	Mar-15	Apr-15	May-15	Jun-15	Jul-15	Aug-15	Sep-15	Oct-15	Nov-15	Dec-15	Jan-16	Feb-16	Mar-16	Apr-16	May-16	Jun-16	Jul-16	Aug-16	Sep-16	Oct-16	Nov-16	Dec-16	Jan-17	Feb-17	Mar-17	Apr-17	May-17	Jun-17	Jul-17	Aug-17	Sep-17
Mechanical Basement								18	18	18	18	12	18	20	20	20	18	15																						
Mechanical Shafts/Risers									3	19	19	19	19	19	19	19	19	19	19	19	19																		
Mechanical Penthouse/Roof																	7	7	15																				
Basement	1	2	1																									10	10										
Level 1		2	2	3								10	10	10	10	10									5		10	10	10										
Level 2					3	3								10	11	10	10	10								5		10	10	10									
Level 3							3									5	10	10	15	10						5	10	10	10										
Level 4								3										3	15	15	10	10						5	5	10	10								
Level 5									3														10	5				6	10										
Level 6										2														5	10					10	10								
Level 7										1										10	10	10	10	10						5	10	10	10						
Level 8											3									10	10	10	10	10							5	10	10	8					
Level 9												2										10	10	10	10	10	10				5	10	10	8					
Level 10												1										10	10	10	10	10	10				5	10	10	7	11				
Penthouse													3										4	4	9	9													
Roof														3									4	4	9	9													
Miscellaneous																					13	8			5	10	17	10		6	11	14	9		6	6	6	3	3
Total Manpower	1	4	3	3	3	3	3	21	24	40	40	44	50	62	60	64	64	64	64	64	62	58	58	58	58	58	57	55	51	51	51	49	49	23	11	6	6	6	3	3